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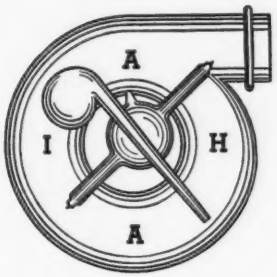

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Volume 10 MARCH, 1949 Number 1

Environmental Aspects of the Industrial Hygiene Study in the Ferrous Foundries of Illinois

Preliminary Report

LUCIAN E. RENES, Engineer
U. S. Pubilc Health Service

THE Public Health Service was approached by several midwestern states to make a study of the health hazards in the ferrous foundry industry. These states had evidence that silicosis was occurring in foundrymen, and believed that a comprehensive study to obtain factual data was desirable. As a consequence, the Public Health Service agreed to undertake such a study in the foundry industry of one state. The Division of Industrial Hygiene of the Illinois Department of Public Health offered to cooperate in such a study and volunteered to make the preliminary surveys of all foundries in their state.

A detailed study of the ferrous foundry industry of Illinois was made during the period beginning about April 15, 1948, and ending about December 15, 1948. The study was made jointly by medical, dental, engineering and laboratory personnel of the Division of Industrial Hygiene of the Public Health Service. In addition, considerable assistance was contributed by various members of the staff of the Illinois Industrial Hygiene Division. The successful progress of the study was due in large measure to the efforts of K. M. Morse, Chief of the Illinois Division, in making the necessary contacts and arrangements with industry and labor groups. Excellent cooperation was obtained from the management of the various plants.

Eighteen ferrous foundries representative of the industry in respect to size, mode of operation, weight of casting and character of casting were selected for the study. Complete environmental investigations were made in each of the 18 plants and complete physical examinations were given to all foundry employees in sixteen of the plants. A detailed work history of each employee was obtained at the time of the physical examination.

In making the engineering survey a time study was made of each occupation in each foundry. Appropriate tests were made at the principal activities of every occupation in each plant. Analysis of collected materials was done almost entirely in the laboratories of the Public Health Service. Dust counts were all made by the field crew in space provided in the laboratory of the Illinois Industrial Hygiene Division or in the laboratory of the Rockford City Health Department.

This is a preliminary report of the environmental findings of the study and is based on the analysis of a portion of the data. A complete analysis and discussion of results will be published at a later date with the complete analysis of the medical findings.

THE FOUNDRY operations of Illinois are performed in large buildings of the type shown in Fig. 1. Large window areas combined with substantial building space afford opportunity for general ventilation by dilution and natural draft during the summer months. Mechanical, roof exhaust fans are provided in most foundries for purposes of general ventilation during cold weather. They are also used in the summertime to supplement natural ventilation during pouring and shakeout. Unit type heat-

Fig. I.
A typical Illinois foundry building

ers are generally employed for comfort heating during winter months. Three of the principal operations, namely, molding, coremaking, and pouring, are usually performed in the same building with no physical barriers between these activities. Shakeout is performed in the same building but is generally done at night after other activities have ceased. In most instances abrasive cleaning of castings is performed in a separate building. These factors of large space, isolation of operation and general ventilation may be partly responsible for the low levels of air contamination observed in these foundries. Their exact influence cannot be stated at this time.

The principal air contaminant with which we were concerned in this study was the dust produced by various foundry operations. An important constituent of this dust is free silica which is present in molding and coresand in large amounts. Analysis of these parent materials showed an average of 75% free silica for molding sand and an average of 86% free silica for coresand. Another important source of free silica is the parting compounds used in molding. Analysis of 12 parting compounds showed a range of 0.5 to 93% free silica. Ten of the samples contained less than 8% whereas the other two contained more than 63%. Since so much free silica is present in these basic materials, one might expect to find appreciable free silica in the airborne dust.

Table I shows the free silica content of airborne and settled dusts collected in the various departments of each plant. Settled dusts were collected from overhead pipes and beams at least 20 feet above floor level. Airborne samples were collected on filter paper in the vicinity of the operation with

TABLE I.
FREE SILICA CONTENT OF SETTLED AND AIRBORNE DUSTS

Type of Dust	No. of Samples	Principal Origin of Dust	Per cent Free Silica Range	Mean
Settled	28	Molding and Shakeout	12-51%	30%
Airborne	15	Molding	16-46	26
Settled	11	Coremaking	18-62	30
Settled	15	Grinding and Tumbling	21-53	30
Airborne	12	Grinding and Tumbling	10-27	17
Airborne	10	Shakeout and Sandcutting	20-40	30

a suction device operating at the rate of about 30 cubic feet of air per minute. Both settled dusts and airborne dusts were passed through a 200-mesh screen before analysis to remove large particles that may have been collected with the sample. It is interesting to observe that the average amount of free silica in the airborne dust of molding and shakeout operations is about 30%, whereas the average amount of free silica in the airborne dust of cleaning operations is only 17%. This difference is readily explained by the nature of the operations. Molding and shakeout involve the handling of much siliceous material. Tumbling operations are exhaust ventilated and preclean the castings of adhering sand before they reach the grinding operations. Analyses of airborne dusts from coremaking areas have not been completed as yet. Limited results indicate about the same percentage of free silica as that found at molding.

THE ANALYSIS of the settled dust samples reveals a curious fact. The average amount of free silica in the settled dust from the molding, coremaking, and cleaning departments is 30% in each case. Even the range of values is similar. In the case of the molding and coremaking areas, the similarity of results may be due to the free interchange of air, since there are generally no barriers between these activities. No explanation can be offered for the similar values of free silica found in the molding and cleaning departments. These activities are usually separate from each other.

Comparison of the free silica content found in airborne dust with that found in the settled dust of the same department is

also interesting. The amount of free silica in the settled dust of the molding area is about the same as that found in the airborne dust of molding and shakeout operations. However, in the case of the cleaning department, the settled dust contains about twice the amount of free silica found in the airborne dust. Results of the analysis of a few samples for iron hint that the difference may be due to the proportion of iron present in the airborne and settled dusts. In the case of the settled dust, the more dense iron may have been elutriated out during the motion of the mixed dust in the air currents. Whatever the cause, these preliminary results indicate that some settled dusts do not reveal the true composition of the airborne dust. Further work is in progress on the fractionation and analysis of these samples for free silica and iron. Perhaps additional information may be revealed.

The character of these dusts is further revealed by their particle size distribution. A number of dust slides prepared from impinger samples were examined for particle size. Measurements were made with a filar micrometer using an oil immersion objective. By count, between 40-70% of all particles were under one micron in size, and between 85-95% of all particles were under three microns in size, depending upon the source of the dust. This seems important since many investigators feel that only those particles under 3 microns in size are hygienically significant.

These analytical and microscopic results confirm previous findings of this Division and results obtained by other investigators.

About 1000 dust samples taken with the standard impinger were collected in the breathing zone of workers at various foundry operations. Counts were made by the standard light field technique within 24 hours after collection. The number of samples taken at any one activity in the plant in which it was performed depended upon the number of persons involved in the job and the apparent magnitude of the exposure. The wide fluctuations in dust production which occur at any activity were taken into account in the number of samples collected.

TABLE II shows the dust levels found at molding, pouring, and coremaking jobs.

TABLE II.
DUST LEVELS AT MOLDING, POURING AND COREMAKING—ALL PLANTS

Operation	No. of Samples	Millions Particles Per Cubic Foot		
		Range	Median	Mean
Bench Molding	24	0.1—10.1	2.1	2.7
Machine Molding	57	0.4— 7.6	2.5	2.6
Floor Molding	40	0.1— 6.2	2.7	2.6
Pouring	32	0.1— 4.2	1.9	1.9
Sandslinging	14	2.8—58.4	12.2	19.1
Finishing sandslinger molds	20	1.4— 7.7	4.6	4.7
Bench Coremaking	39	0.1— 5.2	1.2	1.5
Floor Coremaking	9	0.1— 3.6	1.1	1.3
Machine Coremaking	8	0.9— 3.5	2.6	2.3

With the exception of sandslinging, the average dust levels at these jobs are so low as to appear inconsequential. The relative magnitude of the exposures found at bench, floor, and machine molding are surprising. For all purposes they are identical, and yet one would think that the jolt and squeeze movements of machine molding would create more dust. Apparently the moisture in the molding sand and the oils and other additives of the core sand are strong dust suppressors. However, at sandslinging, the sand is projected into the flask by the machine with great force. Unless excessive moisture is present in the sand, considerable dust is created which contaminates the surrounding area. The higher average dust level found at the finishing of sandslinger molds is primarily due to the dust from the sandslinger.

An important source of dust at molding operations is the dry parting compounds. Our time studies of machine molding showed that it required about three minutes to make a mold; of this time, one-half a minute was used in applying the parting. During the course of a workday, more than an hour's time was spent at this dusty operation. This fact was recognized by J. J. Bloomfield of the Public Health Service about 15 years ago. Table III shows a careful time study of a machine molder's dust exposure as made by Bloomfield. The dust concentration during the application of the parting was over 10 times that observed at pouring and other tasks. The significance of this concentration becomes evident when the particle-minute exposure of this job is compared against the total particle-minute exposure of the occupation. The important fact revealed is that the

TABLE III.
MACHINE MOLDERS DUST EXPOSURE

Activity	Time of Exposure in Minutes in a 9 hour day (A)	Av. Dust Exposure in Millions of Particles Per Cubic Foot (B)	Millions of Particle Minutes (A x B)
Parting Compound application	86	25	2150
Pouring	34	2.5	85
Remaining Tasks	420	2.0	840
Totals	540		3075

$\frac{3075}{540} = 5.7$ mpcf. weighted exposure

$\frac{2150}{3075} = 70\%$

parting compound contributes 70% of the molders' dust exposure. If the parting contained little or no free silica, the weighted exposure would represent only about 0.5 million particles of free silica per cubic foot of air. In this case, the parting contained over 90% free silica, and the weighted exposure represented about 4.5 million particles of free silica per cubic foot of air. It is surprising that high silica parting is still used in many plants, although it has received much adverse publicity in past years.

Table IV shows the dust levels found at shakeout and sand preparation jobs. In a few foundries molding, pouring, and shakeout were done more or less continuously. However, in the majority of plants shakeout and sand treatment were done at night after all other operations had ceased. Generally, the men who do the shakeout also do the sand preparation after the castings are removed to the cleaning department. The ranges of dust concentrations found at any one activity are enormous since there are many factors which influence the dust dispersion. Two facts are evident at this time: (1) The shakeout jobs produce far more dust than the sand preparation jobs. (2) The mechanical method of performing a task produces from two to five times as much dust as the manual method of operation. The weighted dust exposures of the shakeout men will be relatively low in many instances due to the low levels of dustiness at the sand preparation jobs which they also perform.

THE DUST levels found at the various operations of the cleaning department are shown in Table V. Most of the average dust levels are relatively low except at portable grinding and the combination job of grinding and chipping. The low average dust level at stand grinding, wheelabrading, abrasive blasting, and tumbling were attained through the use of mechanical exhaust ventilation. At swing frame grinding exhaust ventilation was not employed. Neither was it employed at portable grinding. Yet the average dustiness at portable grinding is over twice that found at swing grinding. No explanation can be offered at present for this apparent discrepancy.* In the case of pneumatic chipping no mechanical control measures were employed. The low average dust level at this operation appears to be characteristic of the operation. Chipping of precleaned castings is not productive of much dust.

TABLE IV.
DUST LEVELS AT SHAKEOUT OPERATIONS—ALL PLANTS

Operation	No. of Samples	Millions Particles Per Cubic Foot Range	Median	Mean
Removing flasks manually	27	<0.1—27	2.6	3.6
Removing flasks with chain or electric hoist	19	0.6—98.5	6.1	10.8
Dragging-out; knocking-off risers and removing cores manually	44	0.1—37.5	2.7	4.7
Dragging-out with a hoist and removing cores with sledge hammer	22	1.0—240	6.3	22.9
Shaking-out castings with a vibrator hoist	13	2.2—341	12.0	75.5
Shaking-out on a mechanical vibrator platform	18	0.6—39.2	8.7	11.0
Cutting and raking sand manually	15	0.1—7.7	2.1	3.1
Cutting sand with small riddlers	19	0.9—30	4.5	7.0
Cutting sand with a disk	12	0.2—7.5	2.9	3.1
Clean-up and odd jobs of very short duration	33	0.1—9.7	1.8	1.9

The upper section of Table VI shows the dust concentrations observed at the various tasks performed by the cupola crew. It can be seen that the mean dust levels are all relatively low with the exception of the one task of cleaning out the cupola. The job lasts 30 to 45 minutes and is performed daily by the chief cupola man. No respira-

*EDITOR'S NOTE: It has been our observation that dust from unventilated swing frame grinders is normally thrown tangentially away from the operator whereas dust from unventilated portable grinders is thrown tangentially from the wheel in various directions, depending on which surface of the casting is being ground. During part of portable grinding operations, this dust is being projected into the breathing zone of the operator to cause his exposure to be appreciably higher than that of the swing frame grinder operator.

TABLE V.
DUST LEVELS AT ABRASIVE CLEANING OPERATIONS—ALL PLANTS

Operation	No. of Samples	Millions Particles Per Cubic Foot Range	Median	Mean
Stand Grinding	43	0.2—93.5	2.9	6.9
Portable Grinding	23	0.2—51.5	10.1	15.3
Portable Grinding & Pneumatic chipping	17	1.1—48.6	6.4	12.8
Pneumatic Chipping	17	0.1—10	2.7	3.2
Swing Grinding	15	1.3—46.1	3.1	6.6
Wheelabrading	15	0.5—11	2.6	3.3
Abrasive blasting (cabinet method)	10	0.4—25.9	2.1	5.6
Tumbling	20	0.7—14.8	2.6	3.2

TABLE VI.
DUST LEVELS AT MELTING DEPT. JOBS AND YARD JOBS—ALL PLANTS

Operation	No. of Samples	Millions Particles Per Cubic Foot Range	Median	Mean
Chipping-out Cupola	13	4.2—487	88.4	123.5
Mudding Cupola	6	0.1—10.5	2.4	3.3
Charging Cupola	28	<0.1—3.2	1.1	1.2
Tapping Cupola	32	0.1—9.1	1.9	2.2
Cleaning around Cupola	14	0.1—13.5	1.8	3.7
General Indoor Activities	28	0.3—5.5	2.6	2.3
General Outdoor Activities	20	<0.1—4.9	0.5	1.0
Sand Unloading	3	62.3—121	66.4	83.2
Other Yard Activities	12	0.1—2.1	0.3	0.6

tory protection was ever observed to be used by these men. This high dust level raises the weighted exposure of the worker from about 2.5 million particles per cubic foot of air (mpcf) to about 10 mpcf. The lower section of the table shows the dust exposures of yard men. A short exposure to a high concentration of dust occurs during the unloading of core sand from railroad cars. No respiratory protection was ever observed in use during this dusty job. In this instance, the weighted average exposure of the worker was raised from about 0.6 mpcf to about 21 mpcf by this high dust concentration. Although the significance of such high exposures for short periods of time is not known as yet, the use of a personal respiratory protective device seems to be indicated in such instances.

In addition to dusts, mixed gases and smokes are often present in the foundry air. One source of these contaminants is the organic materials present in mold cores which are decomposed by the heat of the molten metal. Carbon monoxide is an important constituent of these decomposition products and is released into the air in variable amounts depending upon the size and number of cores in the molds. Except in highly mechanized plants, pouring is performed late in the afternoon for a period of about one hour. During the summer months when natural ventilation was at an optimum, the CO concentrations seldom exceeded 50 parts per million. However, during cold weather, in those plants not equipped with forced general room ventilation, the CO concentrations reached 400 parts per million in the workers' breathing zone. The short exposure time and the exit of workers into fresh air at the completion of pouring reduced the significance of these exposures.

This study of the ferrous foundries of Illinois included the investigation of many other phases of the environment, which can only be mentioned at this time. Tests were made for gases other than carbon monoxide, and measurements were made of illumination and noise levels in the work rooms. In addition, studies were made of various measures employed in the control of dust dispersion.

Several states have published results of studies made in their foundries. Since these studies were made about ten years ago, subsequent changes may have occurred in those plants to alter the reported conditions. With this qualification in mind the following comparison is made: The dust levels observed in the Illinois foundries are on the whole lower than those reported for other states. It would be interesting to know whether these differences still exist or whether the industry as a whole has made marked improvements.

New Insecticides and Rodenticides and Their Health Aspects

H. A. THIEMANN, Engineer
Hartford Accident and Indemnity Company

WITH THE pressing needs of our Armed Forces during the past war for insecticides and repellents to protect our men against the infestation of the insect and pest diseases of the jungle and of foreign lands, DDT with its wide scope of application and use, and its effective residual properties was developed and is used today extensively in protecting human, animal and plant life against many disease carrying insects and destructive pests.

With the end of the war in Europe, the Army sent American scientists into Germany, among whom were chemists to interview German chemists and to uncover German chemical secrets. In this manner information concerning many of the newer insecticides and repellents now produced in the United States was brought to this country. Several of these were discovered by the Germans while synthesizing and testing hundreds of compounds on laboratory animals in their research to develop new and more powerful war gases and military chemicals. These compounds were also tested on cockroaches, flies and other insects to determine their possible value as insecticides. The information obtained by our chemists apparently induced an incentive to explore the synthesizing and testing of other new and additional compounds possessing effective insecticidal properties. As the result, a bewildering array of new insecticides and rodenticides have appeared on the market during the past few years. The following is a review of the available information and data on these newer compounds:

A. Halogenated Hydrocarbons

THE HALOGENATED hydrocarbons comprise the largest significant group of chemicals used in insect and pest control. Besides DDT, they include its closely related analogs, methoxychlor (dimethoxy-diphenyl-trichlorethane), and TDE (tetrachloro-diphenyl-ethane), also known by the laboratory designation of DDD; BHC (benzene hexachloride), also known by the laboratory designation of GBH for the gamma isomer of benzene hexachloride; chlordane (octochloro-methano-tetrahydroindane); and chlorinated camphene commonly known by its trade name Toxaphene.

1. DDT (dichloro-diphenyl-trichloroethane): DDT was first synthesized by a German student in 1874, but no use was found for it until 1939, when a Swiss chemist, seeking a substitute for lead arsenate, found it to be poisonous to the Colorado potato beetle. It is made from chloral and chlorobenzene and contains 50% of chlorine. The great value of DDT as an insecticide lies in its residual action.

It is generally reported by numerous investigators that the toxicity of DDT to man and domestic animals is low. It is a nervous system poison, primarily of central origin, but like other chlorinated hydrocarbons also causes damage to the liver, the heart and other tissues and is toxic by any route of administration. The dust is not irritating to the skin nor can it be absorbed through the skin in the powdered form. However, when in solution with organic solvents or in oil solutions, it is absorbed through the skin and may present a hazard. There appears to be little hazard from the inhalation of aerosols, mists, sprays or dusts.

A perhaps more important health aspect of DDT is the fact that it is stored in the body fat at a level four to ten times that of the dietary intake. It has been shown to be secreted in the milk of cows, goats, dogs and rats. Other animals fed the milk from the DDT treated animals show toxic symptoms. All the DDT in the milk appears to be concentrated in the butterfat portion, and to be transferred to the butter. Therefore, a relatively small amount of DDT in the whole milk results in a significant amount in the butter. The accumulation of appreciable quantities of DDT in animal tissues at low dietary levels of DDT poses a difficult problem, since many animal products are used for human consumption. This may be especially important in the case of infants and children because of the high consumption of milk.

Presented at the 26th Annual Midwest Safety Conference at Chicago, Illinois.

2. TDE (tetrachloro-diphenyl-ethane): This analog of DDT is also known as DDD (dichloro-diphenyl-dichloroethane) with a chlorine content of 44%. It is also designated by the trade name Rhothan D-3.

The most promising results with TDE so far have been with its use as mosquito larvicides, but laboratory tests have shown it to be unsatisfactory against house flies. It has the advantage of being less toxic than DDT to fish and other aquatic wildlife. Most investigators report it as inferior to DDT in destroying adult insects. In general, it has been found to be inferior to DDT and other organic chlorinated hydrocarbon insecticides in residual toxicity.

Being less toxic than DDT to warm-blooded animals, it is also less toxic to most insects. The acute oral toxicity to rats of TDE is one-tenth that of DDT. However, it should be remembered that acute toxicity bears no relation to chronic toxicity. Its chronic toxicity in rats is one-twenty-fifth that of DDT. In addition to its being a liver toxicant, TDE appears to have a special predilection for the adrenal glands.

3. Methoxychlor (dimethoxy-diphenyl-trichloroethane): The methoxy analog of DDT has a chlorine content of 31%. This material, like TDE, is also less toxic than DDT to warm-blooded animals and subsequently less toxic to most insects. The acute oral toxicity to rats of the methoxy analog of DDT is one-twenty fourth that of DDT. Its chronic toxicity in rats is one-fiftieth that of DDT. Methoxychlor is a kidney poison.

4. Chlordane (octachloro-methano-tetrahydroindane): Chlordane is an American developed material, containing 69% of chlorine, and is now manufactured by two companies in this country. It has been designated or referred to as "1068," or by the respective manufacturer's trade names Velsicol 1068 and Octa-Klor.

Chlordane exerts a relatively strong fumigant action against adult house flies and mosquitoes. It has come into extensive use by pest-control operators and is employed on a large scale in the control of grasshoppers. It is also being used in the control of some insect pests of cotton and certain vegetable crops, as well as for insects of public health importance, such as ants, chiggers, ticks and fleas. Chlordane is reported to be several times as toxic as DDT to house flies and cockroaches, but lacks the long-lasting, or residual property of DDT.

The acute oral toxicity of chlordane to rats is one-half that of DDT, while its chronic toxicity is two-fifths that of DDT. Its toxicity by dermal application in quantities dangerous to man by multiple exposures is approximately four times greater than that of DDT, with moderate irritation noted to the skin.

Chlordane is a poison affecting mainly the central nervous system, particularly the optic center areas. The other principal clinical manifestations of chlordane poisoning, noted in animal experimentation, were liver damage, inanitation, ataxia, convulsions and collapse.

5. BHC (benzene hexachloride): This is another old compound, first made in 1828 by Michael Faraday, but was not tested as an insect poison until 1941 in France. At about the same time the English began experimenting with it and discovered that it was highly toxic to many injurious insects. In England it has been called 666 and Gammexane. It is prepared by adding chlorine to benzene and contains 73% of chlorine.

Although it is superior to DDT for some pest control applications, it lacks the residual action of DDT. This chemical has a strong persistent odor, which is picked up and retained by many fruits and vegetables, and this fact greatly limits its field of usefulness.

Its toxic action against insects may be as a contact poison, a stomach poison, or as a fumigant. The gamma isomer which is the principal insecticidal ingredient, has twice the acute oral toxicity of DDT, but its chronic toxicity in rats is one-fourth that of DDT. It can also be absorbed through the intact skin producing a moderate irritation. It has been shown that clothing impregnated with this agent can cause damage to the central nervous system and to the liver. In toxic doses this compound causes central nervous stimulation leading to convulsions and death. Like DDT, the gamma isomer is stored in the body fat about equal to that of its concentration in the diet. A disturbing feature of the distribution of this poison is its appearance also in brain tissue. It has also been reported that benzene hexachloride becomes translocated into plants.

6. Toxaphene (chlorinated camphene): Chlorinated camphene is made by chlorinating camphene, which in turn is made from pinene, a constituent of turpentine, now extracted from Southern pine stumps on cut-over lumbering lands which was formerly waste material. Chlorinated camphene has a chlorine content of 67-69%. Toxaphene has been accepted as the coined common name for this insecticide. It is also known in the literature as 3956 or Hercules 3956, since it was developed by the Hercules Powder Company.

Toxaphene appears especially promising for the control of all common insect pests of cotton and is effective against grasshoppers, flies and mosquitoes. It does not possess knock down characteristics but its residual toxic effect is reported to compare favorably with that of DDT. Its acute oral toxicity to rats is four times that of DDT.

OF THE halogenated hydrocarbon insecticides, chlordane appears to be the most toxic of the group, followed by chlorinated camphene (Toxaphene) and then the gamma isomer of benzene hexachloride (GHC). Practically all of the compounds of this group injure the liver. The halogenated compounds, although skin irritants in concentrated form, lose this property on dilution and consequently, do not give adequate warning of approaching an overexposure.

Nothing is known of the dangers incumbent to the use of many of the economic poisons as aerosols. DDT has a factor of safety of several hundredfold under such conditions. The hazards of aerosol formulations of chlordane, chlorinated camphene and the gamma isomer of benzene hexachloride can only be surmised. Every precaution should be exercised in their use at this early stage of their development.

B. Organic Phosphates

ANOTHER class of new insecticides is the organic phosphorus compounds, which were discovered by chemists and entomologists of the I. G. Farben Corporation in Germany during the last war. About 20 years ago, the Germans started research on phosphorus-fluorine compounds to develop new and more powerful war gases. Over 300 compounds were prepared and tested on laboratory animals and various insects to determine their value as insecticides.

1. HETP (hexaethyl tetraphosphate): In this manner HETP was developed which proved very toxic to plant lice and was used by the Germans in a formulation called Bladan, as a substitute for nicotine. HETP is easily made by reacting triethyl phosphate, a liquid used in the plastic industry, with phosphorus pentoxide or phosphorus oxychloride.

It is twice as toxic as nicotine to aphids. This fact is of commercial significance, because the demand for nicotine is always greater than the possible supply from tobacco. HETP is also highly effective in killing many other insects and is toxic to warm-blooded animals as well, its acute oral toxicity being 35 times that of DDT.

2. TEPP (tetraethel pyrophosphate): TEPP was independently developed at the University of Chicago. It can be readily made by the same process used in making HETP. This accounts for HETP being a mixture and that its toxicity is due to the presence of about 20% of TEPP.

3. Parathion: Parathion, a new pesticide, an ester of thiophosphoric acid, was also developed in Germany during the war and was known by the code number E-605.

The American Cyanamid Company has pioneered the development and testing of Parathion in the United States, adopting the trade name of Thiophos 3422 for their product. Experiments with this material by over 35 State and Federal Experiment Stations have shown that it is highly effective against a very wide range of insects and promising for control of many pests of agricultural crops. Its residual action on the plants lasts longer. The former belief that it was trans-located into the plant has now been found to be false as it has been shown to break down rapidly in plants and animals to metabolites.

Parathion has been found to act not only as a contact poison and stomach poison, but also as a fumigant. It remains effective for a week or more, both as a contact and stomach poison, and to some extent through continued fumigation effect as the material vaporizes.

Because of the great advantage in speed and convenience of application and labor saving, compared with conventional spraying, all three of the organic phosphate compounds are now available commercially in liquefied gas aerosol bombs containing 10%

by volume of the insecticide agent and 90% of liquefied methyl chloride gas. Methyl chloride is used in preference to Freon because of its cheapness, availability and its superior solubility for the organic phosphate compounds.

The organic phosphate insecticides are freely absorbed from the gastro intestinal tract following ingestion. In addition they are rapidly absorbed through the intact skin, a property which makes them extremely hazardous. They are only slightly irritating when first applied to the skin so there is no immediate warning sign as to the potential danger. The pharmacological action of these organic phosphates produce symptoms of excessive parasympathetic nervous stimulation very similar to that of muscanine poisoning.

The experiments conducted so far to date with laboratory animals have shown that the organic phosphate insecticides are *highly poisonous compounds* and must be handled with great care. Since they are absorbed through the skin, rubber gloves should be worn when handling any of these materials; and to avoid inhalation of the chemicals whether in dusts, mists, aerosols or any other form, the operator must wear an approved type of gas mask with the proper canisters, together with protective clothing and hat. Any material spilled on the skin should be immediately washed off with soap and water. According to Lehman experimental evidence shows that a small drop of undiluted TEPP spattered into the eye might prove fatal to man.

C. Thiocyanates

THE THIOCYANATE group of insecticides, which includes the lethanes (namely Lethane-384, Lethane-384 Special and Lethane-60) and thanite, while not as dangerous poisons as the organic phosphates, have a rapid effect in animals, producing collapse and death within a few minutes. Intact with the skin they produce moderate irritation. Their pathological effect is principally on the liver and damage other organs in general.

D. Piperines

INSECT activators such as piperonyl cyclonene and piperonyl butoxide have a very low order of acute toxicity. However, these synergists when combined with an insecticide not only increase the initial effects of the insecticide by providing quicker knock down and greater kill, but often extend the duration of its residual effect. In this manner, these newer synergists have increased the effectiveness of pyrethrum in insect and pest control work. Combinations of piperonyl butoxide and pyrethrum in various pest control forms of application are especially effective against house flies, roaches, flour beetles, cattle lice and many other insects, but less so against mosquitoes. These combinations are likewise stable and safe to use and are recommended for use in the field, household and food processing plants.

In the recent "DDT Scare," the U.S. Department of Agriculture Entomologists, through a departmental release, recommended the substitution of methoxychlor or the combination of piperonyl butoxide and pyrethrum for DDT in the control of insects on dairy cattle and in dairy barns.

Rodenticides

SIX RODENTICIDES were available before the war, and three of the best were imported. Responding to Army requests, Agriculture Department chemists launched an extensive investigation and screened some 1,500 various compounds. Out of this work two highly effective rodenticides were obtained.

One is the much publicized compound "1080," or sodium fluoroacetate, now being manufactured by Monsanto.

From the brochure prepared by the Insect Control Committee, Rodent Control Subcommittee of the National Research Council, Washington, D.C. entitled, "Instructions For Using Compound 1080 (Sodium Fluoroacetate) as a Rodent Poison" the following is quoted:

"Sodium Fluoroacetate has been found to be highly poisonous to all animals on which it has been tested. It is also considered very toxic to man. When used properly, this poison is a very effective rodenticide. It is recommended for use by responsible and qualified persons such as competent federal, state, county and municipal officers, and experienced professional pest control operators. IT IS NOT RECOMMENDED FOR USE BY THE GENERAL PUBLIC. IT SHOULD BE USED WITH EXTREME CARE.

The absorption of 1080 from the digestive tract appears to be sufficiently rapid to allow for the absorption of lethal amounts

of 1080 before its effects are felt. The ease and rapidity of absorption is a major disadvantage in the treatment of accidental poisoning in man and animals.

There is considerable chance of accidental poisoning to human beings because 1080 may easily be mistaken for some common foodstuffs, as it is fine, white, fluffy powder similar in appearance to flour, powdered sugar and baking powder. It has been suggested that a coloring agent be added to identify the compound and to guard against its being mistaken for the above mentioned items. It should be stored in properly labelled containers. Its presence as a contaminant in food or water might be unrecognized since it is very soluble in water and because of its lack of any particular taste or odor. These facts, coupled with the toxicity of 1080 to man, are of prime importance, especially since *there is no antidote for this poison.*

Although 1080 is not volatile, dangerous amounts of dust may be inhaled. It is recommended that a respirator be worn when handling the pure dry chemcial. The dust also may adhere to clothing; therefore, it should be removed carefully to prevent danger to pets."

The instructions in part contained in this brochure for the attending physician are as follows:

"Compound 1080 exerts its action on the myocardium and central nervous systems in monkeys and presumably in man. The central nervous system reaction is manifested by epileptiform convulsions. The effect on the heart is the primary cause of death. THERE IS NO SPECIFIC TREATMENT."

However the instructions do advise as to what first aid treatment should be rendered, what medicinal preparations should be administered by the physician, specific observations to be noted, and what the general mode of approach is to combating certain accompanying diagnostic symptoms.

Before selling compound 1080 to qualified pest control operators, Monsanto requires a duly authorized person of the purchaser to execute a "Statement and Agreement For Purchase of Sodium Fluoroacetate (Compound 1080)." In this statement and agreement the Monsanto Chemical Company sets forth nine conditions to which the purchaser must affix his signature. One of the conditions being that the organization will have issued to the Monsanto Chemical Company a certificate of insurance of a minimum $50,000/$100,000 limits of public liability insurance for exterminating operations and that the insurance carrier will advise Monsanto whenever this liability insurance may be terminated.

The second rodenticide is "Antu," which is alpha-naphthyl thiourea. When compared with other rodent poisons, Antu is one of the most efficient against the Norway rat, a very common and destructive rat throughout the world.

The Insect Control Committee, Rodent Control Subcommittee of the National Research Council, has released the following information regarding this compound:

"Antu is considerably safer to handle than 1080. However, as with 1080, Antu has *not* been tested directly against humans. It has been shown that monkeys have a high resistance to Antu which suggests that man may likewise have a high resistance."

Richter states:

"Its emetic property protects dogs in most cases. No human fatalities or toxic symptoms in human beings have been observed during three years of extensive use in a city. Antu kills rats and dogs by its action on the capillaries of the lungs, producing drowning pulmonary edema. *No antidote is yet available* but the great insolubility of Antu makes prompt stomach lavage a useful countermeasure."

Comments

MOST OF the insecticides reviewed here are so new that their limitations and their full scope of usefulness in public health practice and agricultural application have not been thoroughly investigated. There has been even less time for studying their toxicity to mammals and warm-blooded animals, including man, and their effects on vegetation and plant life.

Because insecticides are brought in contact with man during application procedures, applied to food consumed directly by man, and sprayed on forage crops fed to animals used for human consumption, toxicological problems associated with their use must be considered from several aspects. These may be listed as studies of the acute and chronic effects, dermal toxicity, the biochemical aspects related to absorption, dis-

tribution, and excretion, and pathologic studies.

Such extensive studies, however, are under way at present on many of these compounds by the Federal Food and Drug Administration, the U.S. Department of Agriculture, the National Research Council, the U.S. Public Health Service, the medical schools of various colleges and universities, by some state experimental stations and other investigators. Until comprehensive information and substantiating data on these phases are available, it is advisable to review data from the literature on public health, agriculture and other biological sciences. This is necessary both for present safety and for the final evaluation of insecticides, which must be selected as much for their harmlessness to man, domestic animals, cattle and vegetation as for their destructive effects on insects threatening human health and plant life.

References

1. LEHMAN, ARNOLD, J., M.D.: The Toxicology of the Newer Agricultural Chemicals. *Bull. of the Ass'n of Food and Drug Officials*, 12:3, July, 1948.

2. ANDREWS, JUSTIN M. and SIMMONS, S. W.: Developments in the Use of the Newer Organic Insecticides of Public Health Importance. *Amer. J. Pub. Health*, 38:5, May, 1948.

3. Brochure: "Instructions for Using Compound 1080 (Sodium Fluoroacetate) As A Rodent Poison" (Revised, July, 1946). Insect Control Committee, National Research Council, Washington, D. C.

4. ABRAMS, HERBERT K., M.D.: Public Health Aspects of Agricultural Chemicals. *California's Health*, State Dept. of Pub. Health, 6:13, January 15, 1949.

5. BLAUVELT, W. E. and HOFFMAN, JULIUS R.: Parathion Aerosol for Greenhouse Pest Control. *N.Y. State Flower Growers Bull.* 29, January, 1948.

6. FAIRHALL, L. T.: Industrial Toxicology—Benzene Hexachloride. *Ind. Hyg. Newsletter*, January, 1948.

7. Brochure: "Instructions for Using Antu (Alpha-Naphthyl-thiourea) As a Rat Poison." Insect Control Committee, National Research Council, Washington, D.C.

8. "The Thanite Family," 2nd Ed., Hercules Toxicants for Insecticides. Naval Stores Dept., Hercules Powder Co., Wilmington, Delaware.

9. Bulletin: "Thiophos 3422 Parathion—A New Pesticide." American Cyanamid Co., New York, New York.

10. ROARK, R. C.: New Organic Insecticides. *The Scientific Monthly*, Vol. 68, January, 1949.

Errata

IN NORMAN G. WHITE'S article "Hydrogen Cyanide as an Industrial Hazard" which appeared in the December, 1948 issue of the American Industrial Hygiene Association Quarterly, the word "Phenolphthalin" was incorectly spelled "Phenolphthalein." This error occurred on page 83 under the heading "Field Procedure for Spot Sampling." At the author's request, correction is hereby made.

Beryllium Phosphor to be Discontinued by Major Manufacturers of Fluorescent Lights

AFTER CONSULTATION with officials of the Public Health Service, Federal Security Agency, the major manufacturers of fluorescent lights have stated that after June 30, 1949, they will no longer use beryllium phosphor in the manufacture of the fluorescent lights, according to an announcement by Dr. Leonard A. Scheele, Surgeon General of the Public Health Service.

For several years the industry has been working with medical men toward eliminating the dangers of beryllium in fluorescent lights. Dr. James G. Townsend, Chief of the Public Health Service's division of industrial hygiene, has been serving as chairman of the Medical Advisory Committee on Beryllium to the industry, which also includes the medical directors of the major manufacturers of fluorescent lights.

The announcement of the June 30 deadline for the use of beryllium in the lights came after Dr. Townsend met recently with a group of executives of the major manufacturers of fluorescent lights.

In view of the fact that the manufacturing changeover in eliminating beryllium will take until the end of June, and there is a stockpile of fluorescent lamps already manufactured, the Advisory Committee emphasized again the instructions it has issued in the past concerning the health hazards in the destruction of the fluorescent lights.

The committee reiterated its assertion to the general public that there is no danger whatever from the lights when they are intact.

The possible dangers come in the destruction of old lights. Recently there have been reports of children who cut themselves on broken lights, and that the cuts healed very slowly and often suffered swelling. The Committee repeated, however, its original statement that such cuts do not cause any general sickness or spread further on the body. Surgical care is necessary if the cut refuses to heal after a period of time.

Although precautions should be taken against breathing the dust from broken fluorescent lights, the Committee said, there is no record of any person suffering injury from breathing dust from the occasional breakage of a lamp, despite the millions of lights in use.

Safe Disposal of Used Fluorescent Lights

THE COMMITTEE reissued its instructions on the safest way to dispose of used fluorescent lights. If there are only a few lights to be broken occasionally, they should be broken out of doors in a waste area or in a waste container, and the person breaking them should avoid breathing the dust or vapor that arises.

The second situation in which there is a possible danger is the breaking of large numbers of fluorescent lamps, either intermittently or regularly, when hours may be occupied in the operation. Instructions in these cases are as follows:

A. Break lamps out of doors in waste disposal area or in ventilated hood. To avoid unnecessary dust, the breakage is best done within the waste container.

B. The operator should be supplied with, and required to wear a respirator approved by the United States Bureau of Mines for toxic dusts.

C. Ultimate disposal of broken lamps should be such that the public and others will not be unduly exposed to powders. In situations where it is necessary to break the lamps within buildings, it should be done in an isolated room and in a hood, so as to minimize escape of dusts. Sufficient exhaust ventilation should be supplied to the hood to provide an air intake of 125 linear feet per minute at all hood openings.

It is recommended that broken lamps not be disposed of in an incinerator, but either be thrown into water or in a dump where they are not likely to be disturbed with evolution of dust.

Significant amounts of mercury vapor may be found in the air during the breaking up of fluorescent lamps. In situations where there is frequent or continuous exposure, measurements should be made of the amounts of mercury vapor in the air during the operation. If high levels are found, protection should be provided for the operator.

Some Relationships of Nutrition to Detoxication

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THE TERM detoxication as currently used is something of a misnomer. Obviously the term implies that the processes involved are those which reduce or destroy the toxicity of harmful substances that have gained entrance to the living organism. Present usage, however, has extended the concept to include all of the metabolic changes which foreign organic compounds undergo regardless of whether the changes result in increased or decreased toxicity.[1] Most workers in the field now look upon detoxication reactions as changes brought about within the body which convert foreign chemicals into their final excreted forms. The conversion products may be more toxic or less toxic than the original material.

Three principal types of detoxication reactions have been recognized: (a) oxidations, (b) reductions, and (c) synthetic reactions. The last of these are sometimes known as conjugation processes. There is a large number of oxidation and reduction reactions, but according to Williams[1] only nine synthetic or conjugation processes have been recognized. These are listed in Table I.

TABLE I.
CONJUGATION REACTIONS

Glucuronic Acid Conjugation
Ethereal Sulfate Conjugation
Glycine Conjugation (Hippuric Acid Synthesis)
Cysteine Conjugation (Mercapturic Acid Synthesis)
Ornithine Conjugation (Ornithuric Acid Synthesis)
Glutamine Conjugation
Thiocyanate Detoxication
Acetylation
Methylation

Several of the conjugation reactions are well known to the industrial hygienist,[2] especially ethereal sulfate conjugation, hippuric acid synthesis and glucuronic acid conjugation. The oxidation of methyl alcohol to formaldehyde and formic acid is also well known as is the reduction of trinitrotoluene to dinitroaminotoluene. In a number of instances, biological oxidation or reduction precedes conjugation.[1]

Since some so-called detoxication mechanisms may give rise to products which are actually more toxic than the parent substance and others may be detoxications in the strictest sense, it might be advantageous to be able to retard or to hasten the reactions. It is commonly believed that the harmful effects of methyl alcohol are due to the oxidation products formaldehyde and formic acid and that the unchanged alcohol can be excreted by the lungs and kidneys. In this case it might be desirable to retard the oxidation. As a matter of fact, several reports on experimental and accidental methanol poisoning treated with ethanol indicate that oxidation of the former is retarded and that the severity of toxic symptoms can be reduced.[3] On the other hand, the oxidation of toluene and its subsequent conversion to the relatively innocuous hippuric acid may be a beneficial process, and one which it might be desirable to hasten.

The fact that nutritional factors may influence the toxicity of many chemicals which are commonly used in industry has been recognized for many years and the subject has recently been extensively reviewed.[4,5,6] Studies now under way and partially reported in this paper would tend to support the idea that in certain instances it is through detoxication mechanisms that the nutritional influences are brought to bear.

Pantothenic Acid and Acetylation

THE RELATIONSHIP between pantothenic acid and acetylation was demonstrated *in vitro* by Lipmann et al in 1947.[7] This observation naturally led to studies to see if the same results could be obtained *in vivo*. While studies were under way in our lab-

The original investigations mentioned in this paper were supported in part by a research grant from the Division of Research Grants and Fellowships of the National Institute of Health, U.S. Public Health Service, and in part by a grant from the National Vitamin Foundation.

oratory, Riggs and Hegsted published evidence for *in vivo* action of pantothenic acid in the acetylation of p-aminobenzoic acid.[8] Our studies have confirmed these observations and have brought to light additional evidence on this subject.

Methods

THE EXPERIMENTAL procedure has been described in detail elsewhere.[9] Briefly, it may be stated that pantothenic acid deficiency was produced in rats by maintaining them on a basal diet of casein (vitamin free), cerelose, corn oil, salts and all necessary vitamins with the exception of pantothenic acid. The control animals received the same diet with the addition of 5 mgm. of calcium pantothenate per 100 gms. of diet.

The rats were kept in individual metabolism cages and urine specimens representing 22 hour periods were collected for analysis. Sulfanilamide was injected intraperitoneally as an 0.8% aqueous solution. Urine specimens were analyzed for the free and acetylated form by the method of Bratton and Marshall.[10] By following this procedure it has been possible to study the effect of pantothenic acid deficiency on one specific detoxication reaction, namely, acetylation of sulfanilamide.

Results

THE RESULTS obtained in one set of experiments are summarized in Table II.

TABLE II.
EFFECT OF PANTOTHENIC ACID DEFICIENCY ON THE ACETYLATION OF SULFANILAMIDE

Days	Deficient Rats % Acetylation (Avg. 8 rats)	Control Rats % Acetylation (Avg. 9 rats)
—4	37.2*	40.0*
70	18.0	34.0
79	16.3	31.8
87	14.1	30.6
94	15.9	32.7
98	14.5	29.6
105	15.1	30.7
	Ca pantothenate	
109	added to diet	—
115	27.2	30.6

*On day —4 acetylation tested with 32 mg. sulfanilamide; on all other days 56 mg. used.

It is apparent that prior to the induction of pantothenic acid deficiency the percentage of acetylation of sulfanilamide was similar for the experimental and control rats. After a period on a deficient diet, acetylation fell in the deficient rats and remained consistently below that of the control animals. Following the addition of calcium pantothenate to the deficient diet (5 mgm. per 100 grams of diet) acetylation rose sharply and approached the normal value.

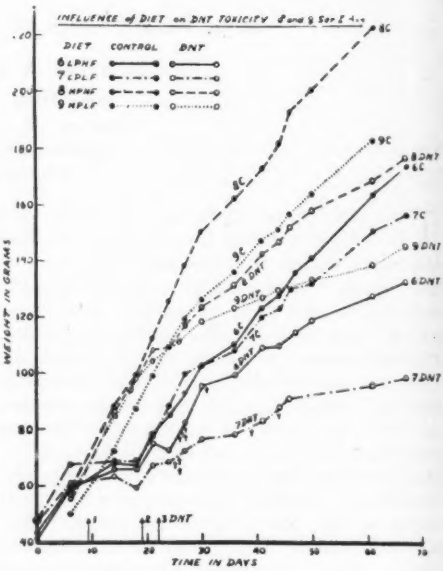

Fig. 1.
Influence of diet on the toxicity of 2.4-dinitrotoluene (DNT)

LP—low protein
LF—low fat
HP—high protein
HF—high fat
Arrow 3 indicates the beginning of DNT feeding (300 mg.% for diets 7 and 9; 600 mg.% for diets 6 and 8). † = death of one rat. Each curve represents the average of 5 male and 5 female rats except where deaths are indicated.

Protein and Fat in Relation to the Toxicity of TNT and DNT

A SECOND type of nutritional influence on toxicity is illustrated by the response of rats to trinitroluene (TNT) and 2,4-dinitrotoluene (DNT) when the amounts of fat and protein in the diet are varied. A detailed description of the experimental procedures and of the results obtained in our laboratory is in the process of preparation and will be published in the near future.[11] We were led to these experiments in part because of the apparently contra-

dictory papers of Himsworth and Glynn[12] in England who claimed that a high fat intake was very deleterious to rats fed TNT and Clayton and Baumann,[13] on the other hand, who reported that a high intake of fat was beneficial to rats receiving the closely related compound, DNT.

Some of our findings to date are summarized in Figs. 1 and 2 and we have drawn the following conclusions from our present data:

1. Both TNT and DNT depress growth regardless of the type of diet.

2. High fat diets *decreased* the toxicity of DNT particularly when the protein intake was low. While the growth effects of a high fat intake on the DNT treated rats were not very marked (notice in Fig. 1 that the controls on the high fat diet also grew better than their associates on the low fat diet) there was an important difference in mortality with DNT between high and low fat diets. In our results to date we have the following figures. On the low protein-high fat diet six of 28 rats have died as compared to 22 of 27 rats on the low protein-low fat diet; on the high protein-high fat diet one of 16 rats has died as against four of 16 on the high protein-low fat diet. These figures also indicate the importance of adequate protein intake in reducing mortality.

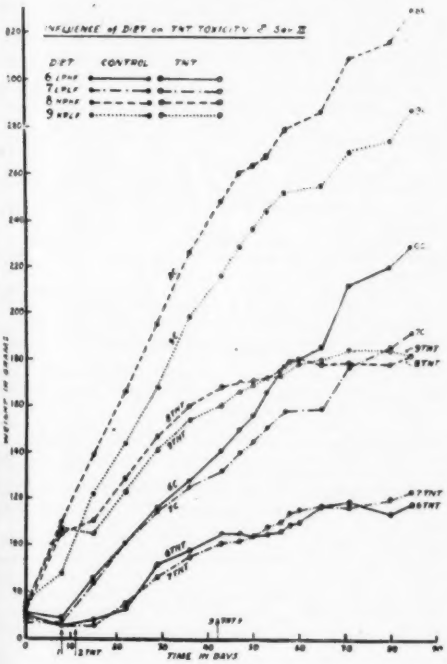

Fig. 2.
Influence of diet on the toxicity of trinitrotoluene
LP—low protein
LF—low fat
HP—high protein
HF—high fat
Arrow 2 indicates introduction of TNT in diets at level of 300 mg.% for diets 6 and 8 and 150 mg.% for diets 7 and 9. Arrow 3 indicates an increase of 25 percent in concentration of TNT in all diets. Each curve represents average weights of 6 male rats.

3. Examination of the effect of increased protein intake on growth reveals that while the rats grew better on the high protein diets than on the low protein intakes as was to be expected, nevertheless the increment of growth of the DNT-treated rats which was due to the increased protein was nearly as much as the increment in the related control groups. The same observation appears to be true in the TNT experiment (Fig. 2). Thus these toxic compounds do not seem to exert their deleterious influence by interference with the protein metabolism involved in growth.

4. The effect of increased fat on the toxicity of TNT was not as clear cut as with DNT (Fig. 2). With the male rats receiving TNT, growth on the low protein-high fat and low protein-low fat diets was about the same. This can be interpreted as meaning that the high fat intake was somewhat more deleterious since the control animals on the high fat diet grew better than those on the low fat diet. In Fig. 2 it is seen that a similar result was obtained with the high protein diets; however, with the males of series I the high protein-high fat diet allowed better growth than did the high protein-low fat diet for both the treated and untreated groups. It would appear from these results that if the protein intake is kept constant, then the fat intake influences growth during TNT administration to a much less extent than would be expected in view of the report of Himsworth and Glynn.[12]

Discussion

THE FACTOR of individual susceptibility to noxious substances is one of the most

baffling problems to confront the toxicologist and the industrial hygienist. It would seem reasonable to assume that if individuals respond differently when exposed to the same environmental conditions, there must be a variable within the individual. Some of the possible variables can be observed or measured, such as anatomical differences in nasal structure or the presence of tuberculous infection as predisposing factors in silicosis. The manner and rate of detoxication of foreign chemicals are other variables which lend themselves to measurement. The studies described here strongly suggest that there may be a relationship between nutritional factors and detoxication mechanisms. If subsequent investigation demonstrates that nutrition is a factor in susceptibility to poisoning by some of the more commonly used industrial chemicals, two major objectives will have been achieved: first, new light will have been shed on the mysterious field of individual susceptibility, and second, a rational basis will be given to the use of nutritional factors in the prevention of occupational poisoning. The possibilities suggested by this approach to industrial toxicology seem great enough to warrant further exploration. The number of possible combinations between toxic compounds and nutritional factors is too large for any ordinary laboratory to encompass. It is hoped that other investigators will find the problem sufficiently intriguing to engage their attention.

Summary

1. Detoxication mechanisms are oxidations, reductions and conjugations.

2. The detoxication (acetylation) of sulfanilamide is impaired in pantothenic acid deficient rats.

3. It is possible that other nutritional factors may be related to individual susceptibility to occupational poisoning.

4. The desirability of more extensive investigation in this field is suggested.

References

1. WILLIAMS, R. TECWYN: Detoxication Mechanisms. New York, John Wiley and Sons, 1947.

2. DREESEN, W. C. and SIEVERS, R. F.: Better Use of Laboratory Procedures. *Ind. Med.*, 15:621, 1946.

3. (a) ZATMAN, L. J.: The effects of ethanol on the metabolism of methanol in man. *Biochem. J.* 40, LXVII, 1946. (b) ROE, O.: Methanol poisoning, its clinical course, pathogenesis and treatment. *Acta. Med. Scand.* 126, Suppl. 182, 1946. (c) AGNER, K. & BELFRAGE, K.-E.: A specific micro-method for colorimetric determination of methanol in blood. *Acta. Physiol. Scand.* 13:87, 1947. (d) AGNER, K., HOOK, O. and VON PORAT, B.: The treatment of methanol poisoning with ethanol. *Quart. J. Studies on Alc.* 9:515, 1949.

4. MILLER, L. L.: Nutritional factors affecting toxicity of halogenated hydrocarbons. *Occ. Med.* 5:194, 1948.

5. SHILS, M. S.: Applying nutrition to industry; diet and resistance to toxic substances. *Jour. Am. Diet. Assn.*, 24:473, 1948.

6. SHILS, M. E. and GOLDWATER, L. J.: Nutritional factors affecting the toxicity of some aromatic hydrocarbons with special reference to benzene and nitrobenzene compounds. *Arch. Occ. Med. and Ind. Toxicol.* In press.

7. LIPMANN, F., KAPLAN, N. O., NOVELLI, G. D., TUTTLE, L. C. and GUIRARD, B.: Coenzyme for acetylation, a pantothenic acid derivative. *J. Biol. Chem.*, 167:869, 1947.

8. RIGGS, T. R. and HEGSTED, D. M.: The effect of pantothenic acid deficiency on acetylation in rats. *J. Biol. Chem.*, 172:539, 1948.

9. SHILS, M. E., SELIGMAN, H. M. and GOLDWATER, L. J.: Pantothenic acid and conjugation reactions *in vivo*. I. The effect of pantothenic acid and thiamine deficiencies on the ability of the rat to acetylate sulfanilamide. *J. Nutrition* 37:227, 1949.

10. BRATTON, A. C. and MARSHALL, E. K. JR.: A new coupling component for sulfanilamide determination. *J. Biol. Chem.* 128:537, 1939.

11. SHILS, M. E. and GOLDWATER, L. J.: The influence of dietary protein and fat on the toxicities of trinitrotoluene (TNT) and 2, 4-dinitrotoluene (DNT) for the rat. *Fed. Proc.* 8:397, 1949.

12. HIMSWORTH, H. P., and GLYNN, L. E.: Experimental trinitrotoluene poisoning. The effect of diet. *Clin. Sci.* 4:42, 1942.

13. CLAYTON, C. C. and BAUMANN, C. A.: Some effects of diet on the resistance of mice toward 2, 4-dinitrotoluene. *Arch. Biochem.* 5:115, 1944; Effect of fat and calories on the resistance of mice to 2, 4-dinitrotoluene. *Ibid* 16:415, 1948.

Notes on Solvent Analysis

J. BRENNAN GISCLARD

THE ACCURATE analysis of solvents and solvent mixtures is a laboratory procedure of exceeding importance to industrial hygienists who must use the data obtained to correctly interpret the degree of worker exposure. When a number of such analyses have to be made, a considerable amount of time must be spent in fractionating, and any supplementary tests which can augment the data obtained by fractionation is always very desirable. The purpose of this paper is to recall attention to a few points concerning the behavior of solvents and to suggest certain additional steps which might be taken as part of the analytical procedure. These supplementary steps have also proven to be very efficacious in certain instances where the amount of solvent available for analysis was comparatively small. They might also be useful in laboratories where no highly efficient fractionating column is available.

Generally speaking, all alcohols, esters and ketones are soluble in concentrated H_2SO_4 and H_3PO_4 so that these reagents may be employed in separating the above solvents from aliphatic and aromatic hydrocarbons by the simple expedient of shaking an excess of the acid with the solvent mixture. In practice, concentrated sulfuric acid has generally been suggested for this purpose. However, reactions occasionally take place which produce dark colored solutions and interfere with the separation and reading. This conditions has been overcome by using 75% acid which is not strong enough to cause undesirable side reactions, yet completely dissolves the solvents mentioned above.

For example, if it is desired to ascertain whether aromatic or aliphatic hydrocarbons are present in a solvent mixture, 10 ml. of the original mixture are placed in a 50 ml. glass stoppered graduated cylinder and shaken with approximately twice its volume of 75% acid. If a layer separates it is read off in terms of percentage by volume. This gives an approximation of the hydrocarbon content, which is very useful information.

Then also, during the fractional distillation the presence of hydrocarbons in each fraction can be estimated by the above procedure. The increasing use of pure hydrocarbons such as cyclohexane and methyl cyclohexane in commercial solvent mixtures gives added possibilities of azeotropes being encountered. Separating these hydrocarbons from the usual alcohols, esters or ketones which form part of the azeotrope is of great value for subsequent identification by means of refractive index measurement, dial reading and boiling point.

In any fractionation where 200 ml. of solvent are employed, 10 ml. fractions are usually satisfactory for plotting refractive index measurements against boiling point. If some of this fraction is to be retained, the amount taken for the acid separation procedure must necessarily be small, but it is possible to utilize as little as 1 ml. if a boiling point is to be obtained by the micro technique described in Schriner and Fuson.[1] This technique does not appear to be widely used in industrial hygiene laboratories. However, trial runs on a few solvents have given results which seem to confirm its use-

This paper which originally appeared in Anachem News in March, 1948 is presented here in view of its value to industrial hygiene personnel.

TABLE I

	First Observed	Second Observed	Average Observed	Actual	Deviation Degrees
	B.P.°C.	B.P.	B.P.	B.P.	
Ethyl acetate	76.0	76.7	76.35	77.0	+0.75
Toluene	109.0	109.0	109.0	110.0	1.00
Methyl iso butyl ketone	114.5	114.5	114.5	114.5-115	0.00
Cyclohexane	79.5	80.0	79.7	80-81	—0.80
Iso butyl alcohol	105.0	107.0	106.0	107-108	—1.50
Amyl acetate	124.0	126.0	125.0	125.0	0.00
Iso amyl alcohol	128.0	129.5	128.7	132.0	—3.30

ful application in identifying compounds familiarly encountered by industrial hygienists. These results appear in Table 1.

It should be noted that the above tests refer to physical methods which might be used along with fractionating. After these separations and tests have been applied, especially to azeotropic mixtures, the other well known chemical tests can be employed where needed with the definite possibility of less interference and a more complete analysis.

References

1. SCHRINER, R. L. and FUSON, R. C.: Systematic Identification of Organic Compounds. New York, John Wiley and Sons, 1948.

Chemical Safety Data Sheets Available Through Manufacturing Chemists' Association

A SERIES of chemical data sheets of much value to industrial hygiene personnel has been prepared covering many of the more commonly used chemicals and additional data sheets are being released as work on them is completed. Designed primarily for supervisory staffs and management, the data sheets present essential information for the safe handling and use of the chemicals. The manuals set forth clearly the important physical and chemical properties of the chemicals; usual shipping containers and methods for their unloading and emptying; container storage and handling, and recommended personal protective equipment. Health Hazards and Their Control are covered authoritatively in a section prepared by the Medical Advisory Committee of the Association. The Chemical Safety Data Sheets may be obtained at 20c per copy (15c for SD-1,-6,-7; 25c for SD-2; and 30c for SD-5) from the Manufacturing Chemists' Association, 246 Woodward Building, Washington 5, D. C. Remittance should be sent with each order. The subjects covered so far as follows: SD-1 Formaldehyde, SD-2 Benzene, SD-3 Carbon Tetrachloride, SD-4 Phenol, SD-5 Nitric Acid, SD-6 Paraformaldehyde, SD-7 Acetylene, SD-8 Anhydrous Ammonia, SD-9 Caustic Soda, SD-10 Caustic Potash, SD-11 Perchloric Acid Solution (Preliminary), SD-12 Carbon Disulfide, SD-13 Aqua Ammonia, SD-14 Trichloroethylene, SD-15 Acetic Anhydride, SD-16 Phosphorus, Elemental, SD-17 Aniline, SD-18 Ethylene Dichloride, SD-19 Dimethyl Sulfate, SD-20 Sulfuric Acid, SD-21 Nitrobenzene, SD-22 Methanol, SD-23 Calcium Carbide, SD-24 Perchloroethylene, SD-25 Hydrofluoric Acid, SD-26 Phosphorus Oxychloride, SD-27 Phosphorus Trichloride, SD-28 Phosphoric Anhydride, SD-29 Ethyl Ether, SD-30 Sodium Cyanide, SD-31 Acrylonitrile, SD-32 Betanaphthylamine, SD-33 Chlorosulfonic Acid.

American Industrial Hygiene Association

—News of the Local Sections—

Chicago Section

SINCE much support of the Chicago Section is derived from members residing in Milwaukee and vicinity, the April meeting is consequently to be held in Milwaukee. Mr. William P. Yant, Director of Research, Mine Safety Appliances Company, Pittsburgh, Pennsylvania is to speak on the subject "Borderlines of Industrial Hygiene and Safety."

The May meeting is to be held on the 18th in Chicago and will be addressed by Dr. Silas M. Evans, School of Medicine, Marquette University, Milwaukee on the subject "Experimental Studies Pertaining to Fibrous Dusts." Dr. Evans will present some of the new theories regarding silicosis and other related dust problems based on the work which he published in the November issue of the Journal of Industrial Hygiene and Toxicology.

Georgia Section

THE MEETING of March 15 held at Atlanta was addressed by Herbert T. Walworth, Director of the Division of Industrial Hygiene, Lumbermens Mutual Casualty Company, Chicago, Illinois. In discussing the subject "Hygiene of Industrial Air Contaminants," he outlined some of the more common problems presented by noxious materials found in workroom atmospheres and described control measures for reducing exposures to safe limits with special emphasis on exhaust ventilation.

Metropolitan New York

AN AFTERNOON program is to be presented on May 6 at the Lower East Side Health Center, New York City. The following subjects are to be covered: "Some Industrial Hygiene Problems in the Petroleum Industry," N. V. Hendricks, Industrial Hygiene Engineer, Standard Oil Company (N.J.); "The Industrial Hygiene Program in the American Cyanamid Company," William R. Bradley, Chief Industrial Hygienist, American Cyanamid Company; "Study of Mercury Exposure," M. O. Shoid, M.D., School of Public Health, Columbia University; "Personnel Monitoring and Radiation Survey Instruments," Hanson Blatz, Chief, Radiation Section, U.S. Atomic Energy Commission, Washington, D.C.; "Hazards in the Use of Radium Containing Static Eliminators in the Printing Industry," John E. Silson, M.D., Division of Industrial Hygiene and Safety Standards, Department of Labor, State of New York; "A New Sampling and Analytical Technique for Trace Quantities of Certain Aromatic Vapors," J. Brennan Gisclard, Industrial Hygienist, American Cyanamid Company.

Northeastern Ohio

AN ALL DAY meeting is to be held on May 19 at the B. F. Goodrich Research Center, Brecksville, Ohio. Mr. Herbert G. Dyktor, Commissioner, Division of Air Pollution Control, Cleveland, Ohio, served as presiding chairman. Following a welcoming address by Dr. Howard F. Fritz, Vice President in charge of Research, B. F. Goodrich Company, Akron, the following program was presented: "The Engineering Control of Occupational Health Hazards," Benjamin F. Postman, Employers Mutual Liability Insurance Company, Newark, New Jersey; "Air Pollution," Dr. H. H. Schrenk, Chief, Environmental Investigation, Division of Industrial Hygiene, U.S. Public Health Service, Director of Donora investigation, Pittsburgh, Pennsylvania; "Experience with Some Common Organic Solvents," Dr. James H. Sterner, Associate Medical Director, Eastman Kodak Company and Consultant, Atomic Energy Commission, Rochester, New York, and "The Value and Significance of the President's Conference on Industrial Safety," James I. Banash, Consultant Engineer, Chicago, Illinois, and Chairman, Sub-committee A of Engineering Committee, President's conference on Industrial Safety, Chicago, Illinois. Mr. Banash's remarks will be submitted by Mr. W. L. Wolford of the Wage and Hour and Public Contracts Division of the Department of Labor. A tour of the Research Center is to be a feature of the meeting.

Philadelphia Section

DR. ALLEN D. BRANDT, industrial hygiene engineer, medical division, Bethlehem Steel Company and president of the Philadelphia Section of the American Industrial Hygiene Association presided at the Phila-

delphia Regional Safety Conference held on March 15. J. D. Townsend, chief, industrial hygiene division, U. S. Public Health Service, Washington, D.C., presented the paper "History of Industrial Hygiene and Services Available to Industry." "Industrial Hygiene in the Chemical Industry and the Solution of Typical Problems" was discussed by A. G. Kammer, Medical Director, Carbon and Carbide Chemicals Corporation, South Charleston, West Virginia. "The Solution of Typical Engineering Problems" was discussed by W. C. L. Hemeon, engineering director, Industrial Hygiene Foundation, Pittsburgh, Pennsylvania.

Officers of the Philadelphia Section in addition to Dr. Brandt as president, are president-elect, K. R. Doremus, Pennsylvania Department of Health, Division of Industrial Hygiene; Secretary-Treasurer, E. L. Schall, New Jersey Department of Health, Division of Industrial Hygiene; directors: W. W. Matthews, Philadelphia Safety Council; W. S. Johnson, Bethlehem Steel Company; J. G. Gaskill, Mine Safety Appliances Company, and V. H. Kindsvatter, Philadelphia Naval Shipyard.

Pittsburgh Section

AT THE February 9 meeting Mr. C. S. Weil of the Chemical Hygiene Fellowship, Mellon Institute, spoke on "The Numbers Game in Industrial Hygiene." Mr. Weil presented an excellent discussion of statistical methods in evaluating results of experimentation.

On March 17, Mr. George Clayton and Dr. W. Davis of the U.S. Public Health Service and Mr. W. H. Hoecher of the U.S. Weather Bureau gave an interesting discussion of various phases of the Donora investigation and explained the methods that were utilized.

Personnel changes among the Pittsburgh Section members included the transfer of Dr. H. H. Schrenk, from the U.S. Bureau of Mines to the U.S. Public Health Service. Mr. E. C. Barnes was appointed manager of industrial hygiene in the new Atomic Power Division of the Westinghouse Electric Corporation. Mr. H. W. Speicher was appointed to the position of industrial hygiene engineer for the Westinghouse Electric Corp. with activities located in the headquarters medical department.

Authoritative New Book

THE FIRST volume of a comprehensive book, "Industrial Hygiene and Toxicology" edited by Frank A. Patty, a past president of the American Industrial Hygiene Association, and Director, Industrial Hygiene Service, General Motors Corporation, has just been released. Both this volume and the second, which is to appear shortly, include chapters on the more important features of the general subject by authorities in their respective fields, including a number of chapters by the editor. This book should serve a most useful purpose as a text and reference book on the subject. The publishers are Interscience Publishers, Inc., New York City.